or;

2) For GaAs, $E_g = 1.42$ eV and the co-orresponding wavelength is;

$$\lambda = \frac{hc}{E_g} = \frac{(6.626 \times 10^{-34}\ \mathrm{J\,s})(3 \times 10^{8}\ \mathrm{m\,s^{-1}})}{(1.42\ \mathrm{eV} \times 1.602 \times 10^{-19}\ \mathrm{J/eV})}$$

$\therefore \lambda = 8.74 \times 10^{-7}$ m or 874 nm

3) Given, $\lambda = 414$ nm

$$E = \frac{hc}{\lambda}$$

$$= \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{414 \times 10^{-7}}$$

$$E = 0.04801 \times 10^{-17} = 4.801 \times 10^{-15}\ \mathrm{V}.$$

4) 5) Mobility of semiconductor μ_p is:

$$\mu_p = \frac{\sigma_p}{pe} = \sigma_p R_H = \frac{R_H}{\rho}$$

where ρ = resistivity $= 9 \times 10^{-3}\ \Omega$-m

$$\mu_p = \frac{3.22 \times 10^{-4}}{9 \times 10^{-3}} = 0.357\ \mathrm{m^2/V\text{-}s}$$

Since R_H is +ve, so the given semiconductor is p-type

NOTES

6) $R_H = \frac{1}{pe}$ where, p = hole concentration

$$p = \frac{1}{R_H e} = \frac{1}{3.22 \times 10^{-4} \times 1.6 \times 10^{-19}} = 19.4 \times 10^{21}\ m^{-3}$$

7) The charge carriers that are present in large quantity are called majority charge carriers. The majority charge carriers carry most of the electric charge or electric current in the semiconductor. Hence, majority charge carriers are mainly responsible for current flow in the semiconductor

whereas,

The charge carriers that are present in small quantity are called minority charge carriers carry very small amount of electric charge or electric current in the semiconductor

8) From the relation, $J = I/A$

$$I = neAV_d$$

Also,

$$V_d = \frac{eE\tau}{m} \Rightarrow I = neA\left(\frac{eE\tau}{m}\right)$$

$$= \frac{ne^2AE\tau}{m}$$

$$\text{or } I/A = \frac{ne^2E\tau}{m} = J$$

Hence $\rho = \frac{m}{ne^2\tau}$

So, for current density J, conductivity $\sigma = (1/\rho)$ where $J = \sigma E$

Mobility $\mu = V_d/E = e\tau/m$

As temp. is constant ~~so~~ so relaxation time will be same and if we double the potential difference the mobility will change accordingly.

9) Direct Band gap

Indirect Band gap

① It is one in which maximum energy level of valence band alligns with the minimum energy level of conduction band with respect to momentum

① It is one in which max. energy level of valence band and minimum energy level of valence band and minimum energy level of conduction band are not aligned with respect to momentum.

② In this direct recombination takes place with energy equal to the difference between energy of recombining particles

② In this due to a diff. in momentum, first momentum is conserved by release of energy and only when the two momenta are aligned, recombination occurs

③ The probability of radiative recombination is very high.

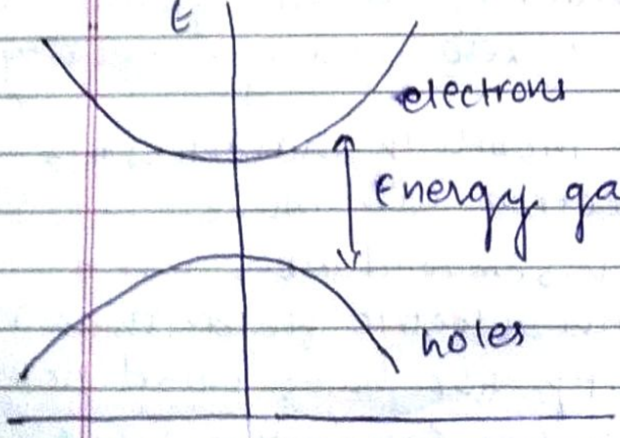
③ The probability of radiative recombination is almost negligible

④ Efficiency factor is high

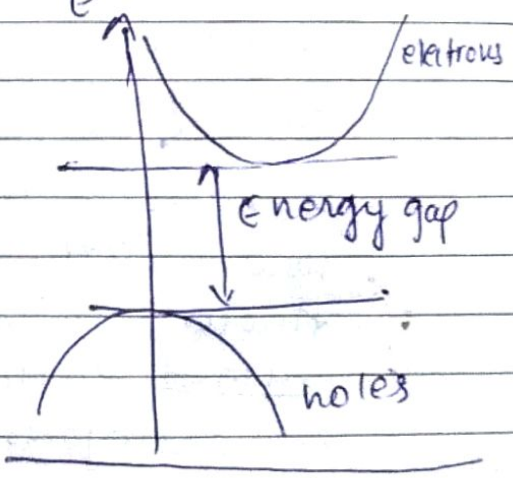
④ Efficiency factor is low

⑤ They are preffered for making optical devices like LEDs e.g:- GaAs

⑤ Cannot be used to make optical device eg:- Si, Ge



Direct band gap semiconductor



indirect band gap semiconductor

Sakshi Srivastava

10) The current density can be defined as the electric current carried by conductor per unit cross-sectional area of the ~~semiconductor~~ ~~per unit~~ conducting medium. We denote the current density with J and $J = I/A$
Here, I is the uniformly distributed current being carried by the conductor of the cross-sectional area A.

The mobility of charge carriers in current carrying conductor can be defined as the net average velocity with which the free electrons move towards the positive end of a conductor under the influence of an external electric field that is being applied.

Same as ques. no. 5

12) ~~It is the a~~ Drift velocity :- It is the average velocity acquired by a charged particle (like an electron or proton) in the body due to an electric field. Usually, an e- inside a conductor moves arbitrarily at the fermi velocity, generating a zero average velocity

Mobility :- In electro mobility characteristics how quickly an electron can move through a metal or semiconductors when ~~plugged~~ pulled by an electric field. There is an analogous quantity for holes called hole mobility. The term carrier mobility refers in general to both hole and e⁻ mobility.

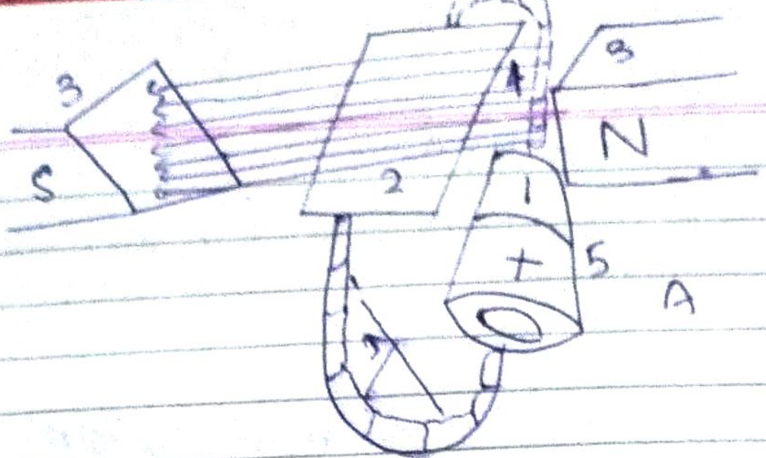
- Equation of mobility: (denoted by μ)

$V_d = \mu E$ $\qquad$ $V_d \propto E$

$$\frac{V_d}{E} = \mu \quad \text{or} \quad \mu = \frac{V_d}{E}$$

$$\boxed{V_d = \mu E}$$

(3)



Hall effect :- It is a current carrying conductor (or semiconductor) is placed in the magnetic field ⊥r to the dirn of current, the magnetic field exerts a transverse force (Lorentz force) on the moving charge carriers which tends to push charge carriers to one side of the conductor. A build-up of charge at the sides of the conductors will balance this magnetic influence, producing a measurable voltage between the two sides of the conductor. This voltage is calle hall voltage (V_H) and this effect is called hall effect

Semi-Conductor

Quest- An electric field of 200 V/m is applied to a sample of n type semiconductor whose Hall cofficient is $-0.0145\ m^2$/Coulomb. Calculate the current density in the sample assuming mobility of electron equals to $0.36\ V^{-1}.S^{-1}$.

Ans

Electric field (E) = 200 V/m

Hall cofficient (R_H) = $-0.0145\ m^2/C$

Current density (J) = ?

Mobility of electrons (μ_e) = $0.36\ V^{-1}S^{-1}$

$$\mu_e = \frac{J}{neE}$$

$$\mu_e = \frac{J}{\frac{1}{R_H e} \times e \times E} \qquad \left(\because n = \frac{1}{R_H e}\right)$$

$$0.36 = \frac{J}{\frac{1}{-0.0145} \times 200 \times 10000}$$

$$J = \frac{0.36 \times 2 \times 10^6}{145} = 4.965 \times 10^3\ m^2/Vs$$

Ques-4:- The carrier concentration in n-type semiconductor is $10^{19}/m^3$. Determine the value of Hall ~~effect~~ cofficient

Ans Given:- $n =$ electron concentration $= 10^{19}/m^3$

R_H (Hall cofficient) = ?

$$R_H = -\frac{1}{ne}$$

$$R_H = -\frac{1}{\cancel{10^{19}} \times 1.6 \times \cancel{10^{-19}}}$$

$$R_H = -0.625\ m^2/C$$ Ans

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Ques14:- Explain Hall effect & derive the expression for Hall cofficient. The carrier concentration in n-type semicond. is $10^{19}\ m^{-3}$. Determine the value of Hall cofficient.

Ans Hall effect explaind in Ques - 13.

Derivation:-

$$F_H = F_m$$

$$F_H = e E_H$$

Now, at equilibrium the magnitude of Hall cofficient force & Lorentz force will be equal.

i.e $e E_H = e v_d B \Rightarrow E_H = v_d B$ — (I)

Current Density,

$J = -n e v_d$ — (II)

divide eq^n (I) & (II)

$$\frac{E_H}{J} = \frac{\cancel{v_d} B}{-ne\cancel{v_d}}$$

$$\Rightarrow \frac{E_H}{J} = \frac{B}{-ne}$$

$$\Rightarrow E_H = R_H B J \quad \left(\because R_H = \frac{1}{-ne}\right)$$

$$\boxed{R_H = \frac{E_H}{BJ} = \frac{-1}{ne}}$$ Ans

R_H = +ive for e^- & -ive for holes.

Given:- $n = 10^{19}\ m^{-3}$

We know $R_H = \frac{1}{-ne}$

$$R_H = \frac{1}{10^{19} \times 1.6 \times 10^{-19}}$$

$$R_H = \frac{1}{1.6}\ m^2/C$$

$$R_H = 0.625\ m^2/C$$ Ans

us-15:-

Ques-15?– Show that in an intrinsic semiconductor the conductivity of the material is given by the expression; $\sigma = en(\mu_e + \mu_p)$, where σ = conductivity, n = carrier density, μ_e = mobility of e^-, μ_p = mobility of holes & e = the electronic charge. The intrinsic carrier density of Ge at 27° is $2.4 \times 10^{17} m^{-3}$. Calculate its resistivity, if the electron & hole mobility are $0.35 m^2/Vs$ & $0.18 m^2/Vs$.

Ans If n_e, n_p represents electron & holes density & v_e, v_p their drift velocities,

$$I_e = e n_e A v_e$$

$$I_p = e n_p A v_p$$

Total Current = $I_e + I_p$

$I = en_e A v_e + en_p A v_p$

$I = e(n_e v_e + n_p v_p)A$ — (1)

we know that $R = \frac{V}{I}$

$R = \rho \frac{l}{A}$

$\frac{V}{I} = \rho \frac{l}{A} \Rightarrow \rho = \frac{VA}{Il} = \frac{EA}{I}$ $\left(\because E = \frac{V}{l}\right)$ — (11)

E = electric intensity.

$\sigma = \frac{1}{\rho}$

$\sigma = \frac{I}{EA}$ ($\because$ from (11))

$\sigma = \frac{e(n_e v_e + n_p v_p)\cancel{A}}{E\cancel{A}}$ ($\because$ from (1))

$\sigma = e\left[n_e\left(\frac{v_e}{E}\right) + n_p\left(\frac{v_p}{E}\right)\right]$

$\sigma = e(n_e \mu_e + n_p \mu_p)$ $\left(\because \mu = \frac{v}{E}, \mu = \text{mobility}\right)$

~~Hence proved.~~

For intrinsic semiconductor $n_e = n_p = n$

$\sigma = ne(\mu_e + \mu_p)$ Hence Proved

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Given:- $n = 2.4 \times 10^{17}\ m^{-3}$
$\mu_e = 0.35\ m^2/Vs$
$\mu_p = 0.18\ m^2/Vs$

We know that

$$\sigma = ne(\mu_e + \mu_p)$$

$$\sigma = 2.4 \times 10^{17} \times 1.6 \times 10^{-19} (0.35 + 0.18)$$

$$\sigma = 3.84 \times 10^{-2} (0.53)$$

$$\sigma = 2.03 \times 10^{-12}$$

Here $\sigma = \frac{1}{\rho}$

Resistivity $(\rho) = \frac{1}{2.03 \times 10^{-2}} = 49.26\ \Omega m$